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Biosensor-based Methods: the instrumental link between biology and physics

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The list of potential chemical contaminants relating to food and food production is very long and encompasses a wide diversity of compounds ranging from natural occurring compounds, such as myco- and phycotoxins, to xenobiotics, such as agricultural chemicals and veterinary drugs. The need to be able to accurately measure the presence of these contaminants, which may be present in primary agricultural products and foods, is driven by a combination of safety concerns and pressures relating to international trade. The true health-related consequences of consuming very low concentrations of multiple contaminants are far from understood. In the opinion of the authors, this is one of the largest and potentially most important knowledge gaps in food safety science today. Current understanding of the adverse health impacts of certain chemicals in foods relates only to toxicology studies performed on single compounds and all scientific efforts have been focused on ensuring that only 'safe concentrations' of these chemicals are permitted to enter the food chain. While the techniques available to scientists to measure ever decreasing amounts of particular chemicals in foods have undoubtedly improved, the ability to measure multiple contaminants is still very much in its infancy. A European funded research project entitled BioCop; New technologies to detect multiple chemical contaminants in foods (www.Biocop.org) is currently highly active in developing a range of techniques which may radically improve the ability to detect the presence, or indeed the biological effects, of a wide range of unwanted chemicals present in many agri-food commodities. One of the technology platforms being developed by the Swedish company, Biacore, is based on optical biosensor technology, which utilises the phenomenon of surface plasmon resonance (SPR). SPR stems from one of the basic principles of optics, i.e. that of total internal reflectance. The Biacore SPR system can monitor almost any molecular interaction as long as one of the interaction partners can be immobilized on a sensor surface. There have been numerous applications for this technology in the field of life science research. However, during the past 10 years, the technology has been proven to deliver some very important improvements to the ability to detect a wide range of chemical contaminants present in agricultural commodities and foods. To undertake this type of analysis has meant that huge efforts to generate very high quality binding proteins to a range of chemicals has been achieved and applications for toxins, pesticides, veterinary drugs and many other contaminants can now be found. Within BioCop, a very new array based and high throughput SPR device is being produced. This will give the method developers the capacity to detect many more contaminants in a single analysis. One of the major research goals within the project utilising this platform is work on detecting the illegal administration of anabolic steroids to cattle. The underlying scientific principle is to detect a panel of protein biomarkers, which have been shown to have their circulating concentrations altered as a result of steroid treatment of cattle. Hence, we have an analytical instrument with its measuring capability based on pure physics being used to detect fluctuations in biological components of serum, i.e. a working example of an interface between biology and physics. If the biomarker study is a success, the research opens the doors to the detection of many other biomarker profiles relating, not only to detection of unwanted chemical contaminants but also to a vast array of other parameters such as the health and disease status of the animal.

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Monitoring methodologies to assess the exposure to steroid hormones and drugs such as anabolic agents, but also contaminants such as dioxins, focus on the usage of sophisticated, detailed analytical individual chemical entity analysis. Although the sensitivity and specificity of these methods is excellent, they have the disadvantage of not encompassing compounds with similar biological activity but with a different chemical structure (for instance anabolic designer steroids). Traditional chemical-analytical methods may then fail to detect compounds, which are not explicitly looked for. By using a biological endpoint rather than the chemical nature of compounds as an endpoint of analysis, bypassing detection is hardly possible. As a mechanism-based bio-analytical approach, CALUX® (Chemical Activated LUciferase eXpression) bioassays are highly selective and extremely sensitive, and have potential to be used as broad (pre-) screening tools for various activities out of established norms in various fields of application such as functional foods, veterinary drug residue analysis, but also sport doping [1–3]. As an example of the latter, in collaboration with the World Anti-Doping Agency (WADA), steroid compounds from the WADA prohibited list and human plasma and urine samples were screened for androgenic, estrogenic, progestagenic and glucocorticoid activities by means of CALUX bioassays, showing that these bioassays are excellent tools for steroid detection. Results from the human sport doping program can easily be extended to veterinary analyses, resulting in an integrated system of control using a combination of bioassays and chemical-analytical methods, providing a system that is able to detect the use of almost any compound that interferes with normal steroid hormone action.

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